

#### **TYPHOON DAN 06W**

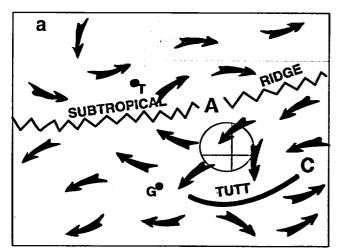
### I. HIGHLIGHTS

After Cam (05W) dissipated in the mei-yu front during the last week of May, there were no significant TCs in the WNP until early July when Dan formed. The tropical disturbance which became Dan was associated with the tropical upper-tropospheric trough (TUTT) and with cyclonic circulations (TUTT cells) within it. Scatterometer data received on 07 July resulted in JTWC doubling the radius of gales on the warning, and ship reports of 60 kt (31 m/sec) provided crucial ground truth for the intensity after Dan recurved and was becoming extratropical.

#### II. TRACK AND INTENSITY

During June, the WNP tropics were inactive. There were no significant TCs, amounts of deep convection were below normal, low-level winds were anomalously easterly and upper-level winds were anomalously westerly (Climate Prediction Center (CPC), 1996). In early July, the Southwest Monsoon remained inactive in the WNP with large-scale climatic wind anomalies similar to those of June. The tropical disturbance which became Dan was associated with the TUTT (see the discussion section), and first appeared as an inverted trough in the low-level easterly flow (Figure 3-06-1a, b). This disturbance was first mentioned on the 031700Z July Significant Tropical Weather Advisory. This advisory included the comments:

"... An area of convection is located near 21N 155E. Satellite imagery and synoptic data indicate a closed circulation exists within a... TUTT. Animated infrared satellite imagery indicates the circulation of this TUTT cell has likely built down to the mid-levels of the atmosphere. Convection near the center of the TUTT cell has improved over the past 6 to 12 hours...."



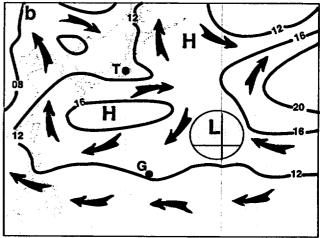


Figure 3-06-1 (a) An area of deep convection (shaded circle) forms in the diffluent northeasterly flow between the axis of the TUTT and the subtropical ridge at 200 mb. (b) At the surface, the area of deep convection (shaded circle) is associated with an inverted trough in the easterly flow southwest of a subtropical high. Arrows depict wind direction, A = anticyclone, C = TUTT cell, L = low pressure, G = Guam, and T = Tokyo. Analyses are adapted from the 021200Z July NOGAPS 200-mb and SLP products.

When synoptic data showed that a low-level cyclonic circulation was located beneath an area of organized deep convection, the JTWC issued a Tropical Cyclone Formation Alert, valid at 041951Z. At this time, the LLCC and most of the deep convection were located to the northeast of

a TUTT cell. The first warning on Tropical Depression (TD) 06W was issued, valid at 050000Z, based upon satellite intensity estimates of 25 kt (13 m/sec).

Dan intensified to a tropical storm at 061200Z, and at 080000Z became a typhoon (Figure 3-06-2). A scatterometer pass over the cyclone at 071304Z (Figure 3-06-3) resulted in a large increase in the radius of gales reported on the warning valid at 071800Z (see the discussion). After becoming a typhoon, Dan turned toward the north and reached its peak intensity of 75 kt (39 m/sec). Moving on a poleward-oriented track, Dan's intensity changed very little for three days following the peak: at 100000Z the intensity was 70 kt (36 m/sec), at 110000Z it was 65 kt (33 m/sec), and at 120600Z it was still at 60 kt (31 m/sec) despite reaching 45°N.

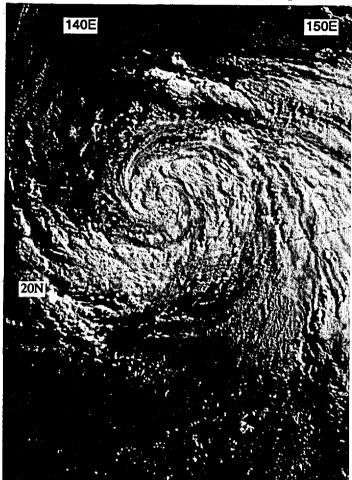


Figure 3-06-2 Dan becomes a typhoon (072040Z July visible DMSP imagery).

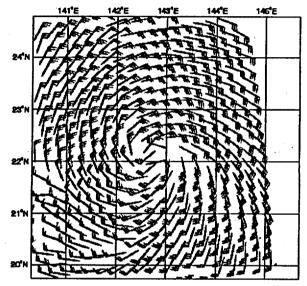


Figure 3-06-3 Scatterometer-derived wind speeds in a swath that passed over Dan (071304Z July ERS-2 scatterometer-derived marine surface wind speeds). This product was used in real time to expand the area of gales on the TC warning.

After 111200Z, satellite intensity estimates began to fall. Based on synoptic data, intensity estimates of Dan after 111200Z were kept significantly higher than satellite intensity estimates (Table 3-06-1). The problem of dropping the satellite intensity estimates far too low as a TC becomes extratropical is long-standing. During 1996, JTWC

satellite analysts developed and implemented a new technique for estimating the intensity of TCs which are undergoing extratropical transition (Miller and Lander, 1996) (see the discussion).

The JTWC issued the final warning on Dan, valid at 120600Z, as the system moved eastward and completed its extratropical transition.

### III. DISCUSSION

# a. TUTT-related genesis

Dan (06W) originated and developed in association with a TUTT cell. Typical of TCs which develop in association with TUTT cells, Dan formed at a relatively high latitude (20°N), and as Figure 3-06-1 indicates, the system developed in the low-level easterly flow on the southwest flank of a subtropical high. For a more complete discussion of TUTT-related TC genesis, see Carlo's (33W) summary. In Carlo's (33W) case, and also in the case of Joy (12W), water-vapor imagery very clearly depicted the process of TC genesis associated with a TUTT cell. The formation of Dan (and also of Eve (07W)) in association with TUTT cells was more complicated than that of Carlo (33W) or Joy (12W), and its description is beyond the scope of this summary.

## b. Scatterometer aids diagnosis of wind distribution

On the warning valid at 071800Z, the radius of 35-kt (18-m/sec) wind was nearly doubled from its value on the warning valid at 071200Z. This large change in the wind radius was based upon scatterometer data from the European Remote Sensing Satellite-2 (ERS-2) (Figure 3-06-3). Comments on the 071800Z warning included:

"... The most significant change in this warning compared to the previous warning is the sudden change of wind radii, which is based on satellite scatterometry data from an overhead pass of the European ERS-2 polar orbiter..."

The JTWC has access to scatterometer wind data, and has used it to help determine the position, intensity and wind distribution of TCs. Some drawbacks of the scatterometer data are its small swath width, 180° directional ambiguity, relatively coarse resolution, an upper limit on the wind speeds that it can accurately detect, and a low-speed bias. For a more detailed discussion of scatterometer data, see Rick's (22W) summary.

# c. On the intensity of TCs undergoing extratropical transition: the "XT" technique

For many years, the JTWC has had a problem diagnosing the intensity of TCs as they undergo extratropical transition. In general, the application of Dvorak's techniques to these systems has resulted in intensity estimates that are significantly lower than what is reported by ships or land stations. An extreme example of this problem occurred during the approach of Seth (1994) to Korea which is highlighted in Seth's summary in the 1994 ATCR. Dan provided another good example of this problem: as it was becoming extratropical (Figure 3-06-4), the satellite intensity estimates fell to values that were later proven to be far too low when compared to ship reports (Table 3-06-1). Attempts to apply Hebert and Poteat's (1975) techniques for estimating the intensity of subtropical cyclones to these systems were not successful.

In order to address the problem of underestimating the intensity of TCs undergoing extratropical transition, satellite analysts at the JTWC in conjunction with ONR-supported researchers at the University of Guam devised a technique (Miller and Lander, 1996) for estimating the intensity of TCs undergoing extratropical transition. This technique yields XT (for extratropical transition) numbers that equate to wind speeds identical to Dvorak's T numbers of the same magnitude. The technique also defines the completion of extratropical transition. On the few independent cases for which it was applied during 1996 the technique appears to have worked well. Though operational, the technique may be refined as more cases are examined. Specific details are beyond the scope of this summary, and those interested are invited to request a copy of the Miller and Lander (1996) technique.

## IV. IMPACT

Skirting east of Japan, Dan drenched the Tokyo metropolitan area with over 5 inches of rain, and over twice that much in the adjoining Chiba prefecture. High water stalled trains and flooded streets. In Chiba prefecture, 29 houses were evacuated and at least 200 were reported damaged by flooding.

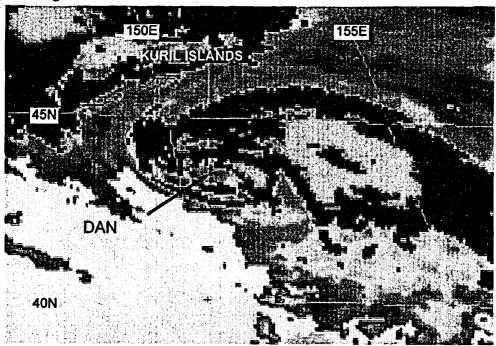


Figure 3-06-4 Dan begins its extratropical transition. Satellite intensity estimates as low as 35 kt (18 m/sec) at this time were far lower than ship reports of 60 kt (31 m/sec) used to support the best-track intensity (112031Z July enhanced infrared GMS imagery).

Table 3-06-1 Intensity estimates derived from satellite imagery during Dan's extratropical transition. In the code, T = Dvorak tropical numbers, ST = Hebert and Poteat subtropical numbers, and the number that follows the "/" is the current intensity which is always held higher when the TC is weakening over water.

			Best Track
Time (Z)	Code	Intensity (kt)	Intensity (kt)
101430	T 2.5/3.5	55	65
101432	T 2.5/3.5	55	65
101730	T 2.5/3.0	45	65
102014	T 2.5/3.0	45	65
102032	T 2.0/3.0	45	65
102330	T 2.5/3.5	55	65
110230	T 2.0/3.0	45	65
110407	T 2.5/3.0	45	60
110530	T 2.5/3.5	55	60
110717	T 2.5/3.0	45	60
110830	T 2.5/3.5	55	60
110832	T 1.5/2.5	35	60
111130	T 2.5/3.0	45	60
111432	T 2.0/2.5	35	60
112030	T 2.0/2.5	35	60
112002	ST 2.5/2.5	35	60
112032	T 2.0/2.0	30	60
112330	ST 3.0/3.0	45	60
120530	ST 3.0/3.0	45	60
120703	T 0.5/1.0	25	60
120830	ST 3.0/3.0	45	60